ADDENDUM TO SOIL REPORT

for the

Mt. Ashland LSR Project

Klamath National Forest
Oak Knoll District

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Prepared by: */s/ Tom Laurent,* January 27, *2008*
Tom Laurent, Soil Scientist

EXECUTIVE SUMMARY

The role of the soil scientist in this project was to provide input to the Decision Maker on ways to maintain the productivity capacity of the soils in the project area as defined in the Klamath National Forest's Land Resource Management Plan and Regional Soil Quality Analysis Standards (SQAS). This may be accomplished by implementing the project design features that include soil and watershed resource protection measures.

Soils in the project area have developed in colluvium from granitics rock types, metasedimentary and minor inclusions of serpentinized peridotite. The project area is characterized by gently to steeply sloping topography, including stabilized landslide benches and scarps. Soils in the project area are generally moderately to very deep (24 to 60+ inches) gravelly sandy loams to very gravelly loams. Soil productivities are generally moderate to high (85-224 ft^3/acre/year). Conifer regeneration potentials are high. Existing erosion hazard ratings are low.

Slope in the project area ranges 2 to 75% and the within unit average slope ranges from 15-57%. Average existing total soil cover ranged from 79-99 percent and averaged 94% overall in the project area. Existing CWD ($\geq$20 inches diameter logs) in the sampled units ranged from 0 to12.0 logs/acre and averaged 4.8 logs/acre.

Calculated from 2,630 soil plots, approximately 10.1% of the project area has been disturbed from past activities excluding system roads. Approximately 4.4% of this disturbance exceeds the Forest's soil quality thresholds for detrimental disturbance. Seventy-fire percent of the disturbance is existing skid trails, 15% is full bench skid trails, 5% is existing temp roads, 1.5% is old rail road logging troughs (from dragging logs), 1.5% is tractor scalped areas, 1.5% is terraces, 0.25% is old tractor piles and 0.25% is old water ditches. Currently, approximately 96% of the soils in the project area have well functioning physical and biological systems**.**

No Action + Wildfire

The modeled wildfire would result in the following soil burn severities: 13% high, 11% moderate and 73% low+unburned. This compares to an average of 9% high, 22% moderate and 69% low+unburned from 1977-2007 wildfires on the Klamath National Forest.

Depending on slope steepness, first-year soil erosion from areas with a high burn severity with sandy loam soils (granitic soils) would range from 3.1-5.1 tons/acre on slopes <35% and 9.1-15.0 tons/acre on slopes >35%. In moderate burn severity areas first-year erosion would range from 1.2-3.6 tons/acre on slopes <35% and 3.6-5.9 tons/acre on slopes >35%. In low burn severity areas first-year erosion would range from 0.4-0.7 tons/acre on slopes <35% and 1.3-2.2 tons/acre on slopes >35%.

First-year soil erosion from areas with a high burn severity with loamy soils (metamorphic soils) would average 3.1tons/acre on slopes <35% and 9.1tons/acre on slopes >35%. In moderate burn severity areas first-year erosion would average1.2 tons/acre on slopes <35% and 3.6 tons/acre on slopes >35%. In low burn severity areas first-year erosion would average 0.4 tons/acre on slopes <35% and 1.3 tons/acre on slopes >35%.

The effects of a wildfire would increase the short-term soil productivity loss. Overall, the cumulative effects from past harvesting and wildfire would meet the SQAS detrimental disturbance standard, would not meet the criteria for maintaining surface organic matter in amounts sufficient to prevent significant short nutrient cycle deficits, would meet criteria for detrimental physical conditions but not the short-term criteria for biological conditions. Overall, this alternative has a moderate probability of meeting the LRMP and SQAS standards and guidelines for maintaining long-term soil productivity.

Preferred Alternative

Overall, the Preferred Alternative has a high probability of meeting the six soil resource standards and guidelines and therefore maintaining long-term soil productivity. The main soil concerns are the effects of ground-based mechanical yarding on the soil resource especially in units that have a high percentage of their area with slopes greater than 35%. In these ground-based logging units, trees located on slopes >35% that can not be reached by skid trails on slopes <35% and/or by endlining from skid trails and roads will not be marked for harvest. In addition, in these units any marked trees that can not be reached with skid trails on slopes <35% and/or endlining will be left unharvested.

Increased soil erosion and reductions in soil productivity (compaction and soil displacement) would occur primarily in main skid trails, landings and new temporary roads. The Preferred Alternative includes ground-based mechanically yarding of trees (including tractor endlining) on 1,056 acres. The generally low intensity of planned thinning and fuel reduction activities will minimize detrimental effects on nutrient cycling by minimizing the consumption of the fine organic component (duff mat). The dynamic and highly variable nature of soil processes and ecosystem and its strong buffering capacity reduce the possibility of having any measurable negative long-term effects on soil productivity.

The Preferred Alternative is expected to meet the LRMP and SQAS guidelines for soil cover, porosity, soil organic matter content, surface organic matter levels, soil moisture regime, soil hydrologic function, buffering capacity and maintain a well functioning soil biological system on approximately 85-90% of the ground-based logging acres, 94% of the cable logged acres and 97% of the helicopter logged acres.

Units 332 and 343 currently exceed the Soil Quality Analysis Standards for detrimental disturbance due to past harvesting activities. Units 220, 234, 342, 368, 709 and 756 have a high probability of exceeding the Soil Quality Analysis Standards for detrimental soil disturbance because ground-based yarding will be used and these units currently have 10% or greater existing detrimental soil disturbance. It is estimated that the detrimental disturbance in these units after harvesting will vary from 14-16%. In order to minimize cumulative effects in these units (units

220, 234, 342, 343, 368, 709 and 756) main skid trails with slopes <35% would be subsoiled after yarding is completed. Units 332, 366, 710 and 757 will be helicopter logged, which will not measurably contribute to cumulative effects. In addition, units 332, 366, 710 and 757 are not a good candidates for subsoiling old existing compacted skid trails since 42%, 62%, 40% and 28%, respectively of the area within the units have slopes >35%.

Summary of CWE/USLE Model

Risk ratios for Beaver-Grouse and Deer-Beaver Creek 7th field drainages range from 0.1 to 0.3 over the 1.0 threshold value (Bousfield et al., 2007). This is a very small increase over threshold values and well within the margin of error for this model. Assuming that the logging is spread out over 3-5 years and most of the burning occurs after logging is complete, the risk ratios for the 7th field watersheds with proposed management activities, would be less than 1.0.

Monitoring

Post-project monitoring, as part of the Forest's soil program, would be done to evaluate how well the project met the SQAS and LRMP soil guidelines. Three units (234, 343, 756) logged with ground-based harvest systems will be selected for SQAS compliance monitoring (% area in skid trails + landings, porosity changes in skid trails). Three subsoiled units would be monitored (220, 342, 368). Three mastication and one hand pile units would be monitored for soil cover, disturbance and soil porosity changes. This monitoring will be combined with the post-logging monitoring of units 332, 343 and 366.

I. INTRODUCTION

The role of the soil scientist in this project is to ensure that the methods used to achieve project objectives will maintain the productivity capacity of the soils in the project area as defined in the Klamath National Forest's Land Resource Management Plan (LRMP) and Regional Soil Quality Analysis Standards (SQAS).

Soil Resource Concerns

The overall soil resource concern is to maintain long-term soil productivity in the project area. This can be accomplished by choosing project design features and resource protection measures that ensure the project will meet the Forest LRMP's soil resource Standards and Guidelines (USFS, 1995a) and the Regional Soil Quality Analysis Standards (USFS, 1995b).

II. ALTERNATIVES

No Action + Wildfire

This alternative takes the No Action alternative and assumes a wildfire burns 5,765 acres of forested land. The area burned is the same treatment areas as identified in the Preferred Alternative.

Preferred Alternative

This alternative plans to treat 5,765 acres of forested land. This alternative will commercially thin forested stands with ground-based yarding systems (1,056 acres), skyline (1,610 acres), and helicopter (935 acres) logging systems. This alternative will require 1.7 miles of new temporary spur road construction and 43 new landings. Underburning will be used on 1,297 acres outside of harvest units. Precommercial thinning of small diameter trees, outside of harvest units, will occur on 408 acres. Hand piling of existing down materials in riparian reserves outside of harvest units will occur on 303 acres. Fuel treatments within harvest units will be a combination of hand pile and underburning.

III. AFFECTED ENVIRONMENT

Soil is the fundamental nonrenewable resource on which other forest resources are dependent. Soils are dynamic bodies of mineral matter, organic materials, micro-fauna, vegetation, and air. The sum of these components makes up the soil ecosystem. The soil ecosystem is divided into above ground and below ground components. The above ground component is the forest floor that consists of coarse woody debris, fine organic matter, litter, and duff mat. The below ground component is the mineral soil that consists of mineral materials, organic matter and pore space. Biological activities occur in the forest floor and within the soil.

Soils in the project area have developed in colluvium and residuum from primarily granitic rocks, a lesser amount from metasedimentary lithologies and inclusions of serpentinized peridotite. The project area is characterized by gently to steeply sloping topography, including stabilized landslide benches and scarps. The major soils formed from granitic rocks are Goodwin and Rogue Series at the higher elevations and Siskiyou, Dome and Holland Series at the lower elevations. These soils are predominately deep to very deep (40 to 60+ inches) gravelly sandy loams. These sandy loam textured soils are sensitive to disturbance due to low soil cohesion. Soils formed from metasedimentary rocks are Smokey and Althouse Series at the higher elevations and Neuns, Kindig and Fong Series at the lower elevations. These soils are predominately moderately to very deep (20 to 60+ inches) gravelly loams to very gravelly loams. These loam textured soils are moderately sensitive to disturbance due to moderate soil cohesion. Soils formed from serpentinized peridotite are predominately Dubakella Series. This soil is predominately moderately to deep (20 to 60 inches) very gravelly loam over very gravelly clay loam. These loam textured soils are moderately sensitive to disturbance due to moderate to strong soil cohesion.

Soil productivities in the project area are generally moderate to high (85-224 ft^3/acre/year). Conifer regeneration potentials are high. Existing erosion hazard ratings are low due to high levels of existing soil cover.

Slope in the project area ranges 2 to 75% and the within unit average slopes range from 15-57% (Appendix Table 5). Average existing total soil cover ranged from 79-99 percent and averaged 94% overall in the project area (Appendix Table 4). Existing CWD (≥20 inches diameter logs) in the sampled units ranged from 0 to12.0 logs/acre and averaged 4.8 logs/acre (Appendix Table 6).

Calculated from 2,630 soil plots, approximately 10.1% of the project area has been disturbed from past activities excluding system roads. Approximately 4.4% of this disturbance exceeds the Forest's soil quality thresholds for detrimental disturbance. Seventy-fire percent of the disturbance is existing skid trails, 15% is full bench skid trails, 5% is existing temp roads, 1.5% is old rail road logging troughs (from dragging logs), 1.5% is tractor scalped areas, 1.5% is terraces, 0.25% is old tractor piles and 0.25% is old water ditches.

Region 5 Soil Quality Analysis Standards (SQAS) allow up to 15% of a management unit to exceed individual threshold values. Currently, detrimental soil disturbance (disturbance that exceeds Region 5 SQAS), primarily measured within proposed ground-based yarding units, ranges from 0 to 21% and averages 4.8%. This detrimental disturbance is mostly soil compaction and displacement from past management activities. The project area meets the LRMP and SQAS for soil cover (70-80% cover), porosity (retains >90% existing soil porosity), soil organic matter content (retains >85% of organic matter in upper 12 inches of soil, surface organic matter levels (retains >50% fine surface organic matter, soil moisture regime (internal soil drainage properties remain unchanged, soil hydrologic function (soil permeability remains moderate to rapid) and buffering capacity (soil pH and buffering and exchange capacities remain unchanged) because less than 15% of the project acres currently exceed these individual threshold values. Excluding roads (roads are not managed for growing vegetation), currently approximately 96% of the soils in the project area have well functioning soil physical and biological systems.

IV. ENVIRONMENTAL CONSEQUENCES

Soil project design measures were developed to ensure that the project has a high probability of meeting the following Region 5 Soil Quality Analysis Standards (USFS, 1995a; Weingardt, 2007) and the Klamath NF's LRMP Standards and Guidelines (USFS, 1995b).

The following soil resource design measures are incorporated into the project design standards for the Preferred Alternative.

- No more that 15% of a harvest unit should be disturbed by primary tractor skid trails, cable yarding corridors and landings.
- Eighty-five percent of a harvest unit must meet the Regional soil quality analysis thresholds for total porosity, soil displacement, soil organic matter, soil hydrologic function, erosion and soil buffering capacity.
- Reuse existing skid trails and landings whenever practical.
- No new constructed (full bench) skid trails will be created.
- Skid trail locations will be agreed to by the FS.
- Skidding equipment will be restricted to slopes <35% and operate during dry soil conditions following the wet weather logging guidelines. Skid trails that connect benches in dormant landslide terrane can have minor portions of the skid trails on slopes greater than 35%.
- In ground-based logging units, trees located on slopes >35% that can not be reached by skid trails on slopes <35% and/or by endlining will not be marked for harvest.
- In ground-based logging units, any marked trees that can not be reached with skid trails on slopes <35% and/or endlining will be left unharvested.
- Slopes steeper than 35% that occur within ground-based logging units will be logged by endlining from roads or skid trails. Ground-based logging equipment will be restricted to approved skid trails on ridges and flatter areas (<35% slopes) with endlining used on the steeper slopes between the skid trails.
- Skid trails in ground-based logging units within granitic terrane will not cross headwalls of swales.
- Main skid trails in units 220, 234, 342, 343, 368, 709 and 756 will be subsoiled under dry soil conditions (dry down to 24 inches) with winged rippers to a depth of 18 inches.
- Minimize soil erosion by water-barring all skid trails, mulching with straw or fine slash

(achieve 90%+ cover) the last 25 feet of all skid trails where they enter landings or roads where needed.
- Track mounted masticators can operate on slopes up to 35% when soils are dry down to 10 inches.
- Prevent road runoff from draining onto skid trails, cable yarding corridors or landings.
- New temporary roads would be built, used and closed in the same season of use (prior to winter)
- Retain existing levels or 5 logs/acre of coarse woody debris (logs) >20 inches diameter for soil productivity needs except where excessive numbers of downed trees creates a fuel hazard.
- Protect existing CWD by having skidding equipment and masticators avoid the larger diameter logs as much as practical.
- Post-treatment total soil cover should range from 70-80% depending on slope steepness and fuel reduction treatments.
- At least 50% cover, as fine organic matter (<3 inch material), would be retained in all units.

The soil resource design measures are also listed under the appropriate standard and guideline indicating how the standard and guideline will be met.

The <u>effects of individual management activities</u> on the soil resource (soil productivity) will be assessed for detrimental soil compaction, soil displacement and organic matter removal using the following Region 5 SQAS and the Klamath NF's LRMP Standards and Guidelines. The design features under each of the six standards and guidelines indicate how the project will meet each of the six soil resource standards and guidelines.

1. **Maintain soil productivity by retaining organic matter on the soil surface and by retaining organic matter in the soil profile [LRMP Ch. 4, Sec. 3-3; SQAS 1a, 1c, 1c(1)].**
   - Meet the recommended soil cover amounts (70-80%) in order to prevent accelerated erosion from exceeding the long-term soil formation rate.
   - Retain at least 50% cover as fine organic matter (<3 inch dia. material) in all units.
   - Maintain at least 85% of the existing total organic matter in the upper 12 inches of soil.
   - No more that 15% of a harvest unit should be disturbed by primary tractor skid trails, cable yarding corridors and landings.
   - Reuse existing skid trails and landings whenever practical.
   - Eighty-five percent of a harvest unit must meet the Soil Quality Analysis Standards thresholds for total porosity, soil displacement, soil organic matter, soil hydrologic function, erosion and soil buffering capacity.

2. **Minimize changes in the site's ability to cycle nutrients and maintain site productivity [LRMP Ch. 4, Sec. 6-14; SQAS 1a, 1b, 1c(1)].**
    - Maintain at least 85% of the existing total organic matter in the upper 12 inches of soil.
    - Maintain 30-50% of existing duff mat (spatially).
    - Maintain at least 50% fine organic matter (<3 inches in diameter) on site.
    - Retain at least 70-80% soil cover in order to prevent accelerated erosion from exceeding the long-term soil formation rate.

3. **Retain CWD and protect existing CWD [SQAS (2b); LRMP Ch. 4, Sec. 3-6].**
    - Protect existing CWD by having skidding equipment and masticators avoid the larger diameter logs.
    - Use lower intensity fuel reduction methods (underburns, handpile/burn).
    - Felled hazard trees will be retained on site for CWD recruitment

4. **Minimize soil and litter disturbances resulting from ground based yarding and heavy equipment (LRMP Ch. 4, Sec. 3-5 and 6-16).**
    - Reuse existing skid trails and landings whenever practical.
    - Skidding equipment will be generally restricted to slopes <35% with endlining on slopes exceeding 35%.
    - Track mounted masticators can operate on slopes up to 35%.

5. **Prescribed fire should be planned to minimize the consumption of litter and CWD [SQAS 1a, 1c(2a), 1c(2b)].**
    - Underburning and hand piling will be used to maintain the recommend soil cover amounts and to protect appropriate levels of CWD.
    - Underburning and hand piling will be used to retain at least 50% cover as fine organic materials (<3 inches diameter) with the remaining 20-30% as other types of organic materials and rock fragments.

6. **Maintain the functionality of the soil ecosystem by maintaining a sites ability to cycle nutrients and maintaining the biological components (fungi, arthropods, bryophytes) [LRMP 6-1, 6-2, 6-14(3c), 21-12 and 21-20].**
    - No more than 15% of a harvest unit should be disturbed by primary skid trails and landings.
    - Maintain at least 50% fine organic matter on the soil surface and sufficient duff mat (30-50%)

Detrimental disturbance consists of two main types of disturbance: detrimental compaction and detrimental displacement. Detrimental compaction is compaction that results in a >10% decrease in total soil porosity measured at the 4-8 inch soil depth. Detrimental disturbance is where soil displacement of the topsoil removes greater than 15% of the soil organic matter in the upper 12 inches of soil (disturbed area must be greater than 1 square meter in size).

Soil Cover

The amount, kind and distribution of soil cover necessary to avoid detrimental accelerated soil erosion is guided by the Region 5 Erosion Hazard Rating system (USFS, 1990) and locally adopted standard erosion models and measurements, such as those described in the following papers: Soil Cover Process Paper (Laurent, 2000) and Soil Erosion Processes and the USLE (Laurent, 2001). The Klamath LRMP (USFS, 1995a) Standards and Guidelines are used on the Forest for protecting soil productivity and minimizing soil erosion (see Table 1 below).

Table 1. Minimum total soil cover needed in treated stands in order to minimize soil erosion per LRMP Table 4-2.

Soil Texture Group	Slope Group %	Minimum Soil Cover %
Machine Disturbed Areas		
Sandy loam or coarser (granitics)	0-25	70
	26-35	80
	36-45	80
Loam or finer	0-45	70
Prescribed Fire Areas		
Sandy loam or coarser (granitics)	0-25	60
	26-45	70
	46+	80
Loam or finer	0-35	50
	36-60	60
	61+	70

Soil cover can be any combination of duff mat, litter, fine organic materials (<3 in. dia.), coarse organic materials (>3 in. dia.), live vegetation in contact with the soil and rock fragments (>3/4 in. dia.). The Forest and Regional SQAS require that fine organic materials (duff mat, litter, fine organic materials) be at least 50% (absolute percentage value) of the total cover.

The soil cover guidelines identified in Table 1 were used to determine the recommended post-treatment soil cover needed to achieve low erosion hazard ratings for each management unit. The soil cover guidelines are designed to keep short-term soil erosion rates at or below soil formation rates (approximately 1 inch of soil per 1,000 years). The long-term soil erosion rate will be well below the long-term soil formation rate.

It has been shown from erosion plot data that 50% soil cover (Laurent, 2001) can reduce surface erosion by 70-80% compared to bare soil (0% cover) conditions. Recommended levels of soil cover are designed to result in a low erosion hazard rating. These soil cover amounts can reduce soil erosion by 80 to 88%.

NO ACTION + WILDFIRE ALTERNATIVE

Direct Effects

Under this alternative, there are no management related direct effects because there would be no new soil disturbances from management actions. The existing condition (as of July 2006) of the soil resource is as identified in Appendix Tables 4, 5 and 6. The level of existing detrimental soil disturbance from field gathered data within the investigated project units (primarily ground-based yarding units) was 0-21% and averaged 4.8%. Detrimental disturbance is disturbance that is estimated to exceed Regional and Forest SQAS for soil porosity (compaction) or loss of soil organic matter in the upper 12 inches of soil. In the project area, detrimental disturbance occurs in existing main skid trails and old non-system roads within proposed treatment units.

Average existing total soil cover ranged from 79 to 99 percent (Appendix Table 4). Existing CWD (≥20 inches diameter logs) in the sampled units ranged from 0 to 12 logs/acre and averaged 4.8 logs/acre (Appendix Table 6). Overall, the CWD has continued to increase as trees continually fall by natural events (insect, disease and wind).

The wildfire that was modeled, using the FFE FVS fire behavior model, assumes a wildfire burning in the middle of summer and moving in an upslope direction. There is no backing type burning. The model used three fire types: ground fire (S), passive canopy fire (P) and active canopy fire (A). The ground fire mainly burns the understory vegetation with some scorching of the lower branches of the overstory trees. The passive canopy wildfire moves as a ground fire with scorching of the overstory trees but not canopy consumption. The active canopy fire is a canopy fire that consumes the needles and small branches of the overstory trees as well as the understory vegetation.

The following table displays the average wildfire soil burn severities from 1977 to 2007 and the burn severities estimated from the fire behavior modeling.

Table 1A. Average soil wildfire burn severities over the past 30 years on the Klamath National Forest

Wildfire	High	Moderate	Low + Unburned
1977-2007	9	22	69
No Action+Wildfire	**13**	**11**	**73**

The modeled soil burn severity data in Table 1A for the No Action + Wildfire alternative indicates that more high burn severities will occur due to denser understory vegetation on north and east slopes that allows the wildfire to move into the upper canopy and to the model parameter of all up slope moving fire. There is less moderate burn severities and about the average level of low burn severity. Table D in Addendum #1 to the Mt. Ashland CWE report displays acres of each soil burn severity by 7th field watersheds (Bousfield et al., 2007).

Indirect Effects

Depending on slope steepness, first-year soil erosion (Table 9) from areas with a high burn severity with sandy loam soils (granitic soils) would range from 3.1-5.1 tons/acre on slopes <35% and 9.1-15.0 tons/acre on slopes >35%. In moderate burn severity areas first-year erosion would range from 1.2-3.6 tons/acre on slopes <35% and 3.6-5.9 tons/acre on slopes >35%. In low burn severity areas first-year erosion would range from 0.4-0.7 tons/acre on slopes <35% and 1.3-2.2 tons/acre on slopes >35%. These soil erosion rates would be up to 100% higher in the moderate and high soil burn severity areas if the USLE model had factored in hydrophobicity (fire induced water repellency) in the sandy loam textured soils.

First-year soil erosion (Table 9) from areas with a high burn severity with loamy soils (metamorphic soils) would average 3.1 tons/acre on slopes <35% and 9.1 tons/acre on slopes >35%. In moderate burn severity areas first-year erosion would average1.2 tons/acre on slopes <35% and 3.6 tons/acre on slopes >35%. In low burn severity areas first-year erosion would average 0.4 tons/acre on slopes <35% and 1.3 tons/acre on slopes >35%.

The long-term soil erosion rate that maintains soil productivity is <1.0 ton/acre/year per Regional Soil Quality Analysis Standards. This is 0.0063 inches of surface soil lost with associated soil nutrients. Comparing this to the predicted erosion rates for the wildfire indicates that only the low burn severities would maintain the short-term soil productivity. The high and moderate soil burn severities would show some short-term soil productivity decline but since these soils have developed in a wildfire regime, the natural soil productivity is in rhythm with the wildfire return cycle. It is natural for soil productivity, as measured by biomass production, to decrease after a wildfire, low rainfall years and times when biomass basal area is at a maximum.

Overall, wildfire has an increased potential to have a measurable short-term negative effect on soil productivity that would recover over time as natural recovery processes (such as nitrogen fixing vegetation) occur.

Nutrient cycling would be interrupted in the high burn severity areas and decreased in the moderate and low burn severity areas. Nutrient cycling would increase as fine organic matter accumulates as a litter layer. Compacted soils (reduced porosity) in existing main skid trails will slowly increase their porosity due to biological activities and thereby regain lost soil productivity over the next 40-50 years. Existing old non-system roads will remain as they currently exist.

Cumulative Effects

Cumulative effects on the soil ecosystem are based on the number and types of management activities occurring within an individual stand over time and are measured by effects on soil productivity. The number and types of management activities and their distribution occurring within a watershed were analyzed by the Forest's CWE model process, such as surface erosion and subsequent sedimentation. Cumulative effects were also analyzed on a unit basis. Table 4 displays the existing detrimental disturbance data which represents current cumulative disturbances from past activities. Existing detrimental disturbance ranges from 0-21% and averages 4.8%. Currently 277 acres of the approximately 5,765 project acres exceed the 15% threshold for detrimental disturbance. With no new disturbances, detrimental disturbances resulting from past skid trails will slowly recover.

Wildfire Effects

The USLE component of the CWE model was applied to this hypothetical wildfire scenario with the following results. Post-wildfire sedimentation from surface erosion was increased 143% and 100% in Beaver/Grouse and Long John Creeks, respectively. This increased sedimentation does not include water repellency induced erosion. The risk ratios for Beaver/Grouse and Long John Creek 7th field watersheds were 2.63 and 2.03, respectively. The other 7th field watersheds had only small increases in risk ratios over current conditions. These elevated risk ratios in Beaver/Grouse and Long John indicate that cumulative watershed effects would be evident in the project area.

Soil Productivity

With no new management activities, potential cumulative effects would be the effects of past logging activities. The cumulative effects would be the combined effects of compaction from past tractor logging, soil gouging from past railroad logging, accelerated erosion from past activities and nutrient removal.

The effects of soil compaction in skid trails on soil productivity would be highly variable due to differences in soil texture. The mostly gravelly sandy loam soils would show little to no negative effects and probably a positive effect to biomass growth based on greater soil water availability with detrimental compaction (Powers et al., 2005). The gravelly sandy loam and very gravelly loam soils would show none to some decline in biomass production with detrimental compaction. But Powers et al. (2005) also showed that detrimental compaction had no statistically measurable effect on biomass production (conifer trees) when there was no competing vegetation.

Erosion

Surface erosion from existing disturbed areas, such as existing skid trails, landings, 4x4 trails and non-system roads in the high and moderate soil burn severity areas would increase. However, the amount of increased erosion from these sites after a wildfire would be very minor when compared to the amount of wildfire-caused accelerated erosion across the landscape.

Soil Biology

Soil biological functions would change after a wildfire. The natural seasonal and elevational fluctuations will continue. Biological nutrient cycling will decrease until the litter layer is of sufficient depth to provide the proper micro-environment for biological activity. As the debris on the forest floor increases in thickness in burned areas surface soil temperatures will slowly decrease approximately 4 degrees C.

Summary

Currently, existing detrimental soil disturbance ranges from 0-21% and averages 4.8% for the project area. At the present time, approximately 277 acres out of approximately 5,765 acres exceeds the SQAS threshold for detrimental disturbance. The effects of a wildfire would increase the short-term soil productivity loss. Overall, the cumulative effects from past harvesting and wildfire would meet the SQAS detrimental disturbance standard, would not meet the criteria for maintaining surface organic matter in amounts sufficient to prevent significant short nutrient cycle deficits, would meet criteria for detrimental physical conditions but not the short-term criteria for biological conditions. Overall, this alternative has a moderate probability of meeting the LRMP and SQAS standards and guidelines for maintaining long-term soil productivity.

PREFERRED ALTERNATIVE

DIRECT EFFECTS

Direct effects on the soil ecosystem, by natural or man-caused activities, are primarily soil disturbance, redistribution of organic matter and changes in biological properties. The soil ecosystem properties that are affected are soil volume, soil porosity, soil water availability, soil chemistry and soil biology (Powers, 1989). The following information provides a more in depth discussion of individual management activities and their direct effects on the soil resource.

Ground-based mechanical yarding (1,056 acres) would result in increased soil disturbance and reduced soil porosity but with proper layout of the skid trail pattern, detrimental disturbance (detrimental compaction and detrimental disturbance) can be kept within allowable limits (15% of each unit). Placing a high priority on reusing existing skid trails will help to ensure that the area occupied by skid trails can be minimized. Monitoring data from measuring proposed new skid trails in 3 units in the Beaver Creek watershed showed that 69% of the new skid trails would reuse existing skid trails (ranged from 48-87%). Currently, the level of estimated detrimental disturbance from past activities (existing landings, skid trails, constructed skid trails, temp. roads) ranges from 0-21% and averages of 4.8% in units identified for ground-based mechanical logging. Soil compaction (reduced soil porosity) exceeding Regional and Forest threshold values would occur on the heavily used portions of main skid trails and landings. Some compaction (reduced soil porosity) would occur in other areas where machinery makes one or two passes but this increased compaction would not exceed threshold values as documented by Powers et al. (2002) and Laurent (2006). There is a possibility that the amount of post-logging detrimental disturbance (reduction in soil porosity) could be >15% of the area in units 220, 234, 342, 343, 368, 709 and 756. Unit 337, which will be tractor endlined, would not to be subsoiled due to steeper slopes and no new skid trails. Therefore these units will have their main skid trails subsoiled to a depth of 18 inches after logging in order to bring the level of detrimental disturbance below the 15% threshold. Subsoiling would occur when the soil is dry down to a minimum of 18 inches. Subsoiling of dry soil has been shown to be an effective method of reducing compaction and restoring porosity to the soil (Andrus and Froehlich, 1983; Atzet et. al, 1989). New ground disturbance has a high probability of not significantly impairing soil productivity because only those areas with slopes <35% would be tractor logged. Areas with slopes steeper than 35% that can not be reached by skid trails on slopes <35% and/or endlining would not be harvested. The area within units that would be left unharvested ranges from 0-62% of the unit. For the Preferred Alternative 86% of the ground-based logging units were field reviewed in the field.

Skyline yarding (1,610 acres) would cause small amounts of soil displacement in the yarding corridors from dragging logs. The cable corridor can vary from 6 to 8 feet wide and will have an area in the center of the corridor that is down cut 9 to 12 inches deep (recent personal field observations on Klamath National Forest). When properly water barred, no significant erosion will leave the harvest units. The spatial area of skyline logged units in yarding corridors has been measured as varying between 3 and 8% (Dyrness, 1965; Wooldridge, 1960; Klock, 1975). Currently, the level of estimated detrimental disturbance from past logging activities, primarily by tractors, ranges from 0-12% and averages 3% within units to be skyline yarded. None of the units to be skyline yarded would exceed the 15% detrimental disturbance threshold value.

Helicopter yarding (935 acres) would cause very small amounts of soil disturbance depending on the size of material removed. The soil disturbance occurs when the felled trees hit the ground and cause a small depression to form (soil displacement, compaction, and reduced porosity) in the surface soil. Usually, trees are felled on the contour and no additional soil disturbance occurs. Trees that fall down slope or at an angle to the slope cause some additional disturbance by sliding down slope. Helicopter logging should not result in any additional detrimental disturbance to the soil resource. Currently, the level of estimated detrimental disturbance from past logging activities, primarily by tractors, ranges from 0-19% and averages 6% within units to be helicopter yarded. None of the units to be helicopter yarded would exceed the 15% detrimental disturbance threshold value except for unit 332 which currently exceeds the detrimental disturbance threshold value

Landings (43 new landings) are needed for logging operations. The size of individual landings is guided by safety requirements. Generally, landings are kept to the smallest size practical, approximately 0.25-0.33 acres each but are generally larger when whole-tree yarding is used. Helicopter landings are also generally larger. Existing landings will be reused where possible. Landings will be subsoiled after use, which will reduce soil compaction and improve opportunities for revegetation. Landings can produce erosion and sediment if not properly designed and maintained. Project design standards will provide for long-term erosion control.

Hand piling (1,175 acres) would easily maintain sufficient fine soil cover without causing additional ground disturbance. The associated burning of this piled material should easily meet the required soil cover amount. It is estimated from recent data (Laurent, 2007) that the hand piles could occupy approximately 4 to 25% of the hand piled acres. The percent of acres in hand piles for this project could be up to 25% level due to the high amount of existing down materials. The area in piles could occupy up to 6.7% of project acres. The piles, which are composed of material generally less than 10 inches in diameter, is not compacted and therefore most of the material is not in contact with the soil. Most of the radiant heat will not be focused on the soil but dispersed into the air. Field observations from other projects that had burned hand piles indicated that the duff layer beneath the pile is consumed and the soil surface blackened. This indicates that the burn intensity was in the range of low (higher end of low) to moderate (lower end of moderate). Damage to the soil occurs when the soil color changes to reddish orange (red brick color) which normally occurs under logs and in stump holes during wildfire or broadcast burn intensities of moderate and high. There would be minimal to no significant changes in soil characteristics within the burned pile areas (Dyrness and Youngberg, 1957).

Machine mastication (988 acres) **+ machine mastication/hand pile** (42 acres) of activity created material should maintain the high levels of existing cover by cutting the existing live and/dead standing material into smaller pieces and letting it fall to the soil surface. This treatment increases the thickness of the forest floor layer, which in these high elevation soils, could decrease soil temperatures 4-5 degrees C and reduce evaporation by 15-86% (Powers, 2000). Requiring the track mounted (excavator-type body) masticator to travel and work up and down the slopes (perpendicular to the contour) and using the maximum boom reach will minimize ground disturbance. There will be ground disturbance when the machine turns on slopes due to one of the tracks being locked during the turning process. The equipment will also travel and work over surface organic material that has just been masticated. Monitoring of mastication on the Forest showed that heavy disturbance (travel corridors, track caused scalps, etc) ranged from 0-12% and averaged 5% (Laurent, 2007). Recent soil cover monitoring data (Laurent, 2007) on the Klamath National Forest for mastication in plantations showed that the unit average soil cover retained ranged from 88 to 99% and averaged 96%.

Underburning (3,638 acres) **+ hand pile/underburning** (~80) would result in a minor loss of nitrogen but this will have no measurable effect on soil productivity. The overall forest floor would be adequately maintained. The soil cover requirements would easily be met by this low intensity fuel treatment. Recent soil cover monitoring of underburns on the Klamath National Forest has shown that post-burn soil cover easily exceeds required cover requirements (Laurent, 2007).

Precommercial thinning (408 acres) using hand operated chainsaws should increase existing cover by cutting the existing live young trees and brush into smaller pieces and letting it fall to the soil surface. This treatment increases the thickness of the forest floor layer, which in these high elevation soils, could decrease soil temperatures 4-5 degrees C and reduce evaporation by 15-86% (Powers, 2000).

CWD would be partially affected by the mechanical yarding, masticating of activity created slash and existing downed materials. Some of the more decomposed logs may be disturbed by heavy equipment operations and could therefore loose some of their effectiveness. Sufficient number of trees would remain on site in the project area and CWD increase over time by natural falling of standing trees and snags.

Road maintenance/Upgrade would maintain and/or upgrade existing roads that are currently drivable including existing temporary roads. This work involves blading and shaping of the road surface, installation of rolling dips, culvert replacement, ditch cleaning and clearing of encroaching vegetation along the roadway. This work involves disturbance of soil material within the road prism including in channels and swales.

Temporary road construction (1.7 miles) creates soil disturbance which is generally due to the cut and fill construction technique. Approximately half of the road is cut into the slope while the other half of the road is on the deposited cut material (fill material). Temporary roads are typically 16 feet wide. On flat to gentle slopes, soil disturbance can be minimal to shallow cuts (0.5 to 2 feet). On steeper slopes cuts can be 4 to 8 feet high. The fill material is deposited on top of the existing soil, thereby increasing soil depth which in turn increases soil water holding capacity. Soil organic materials are also incorporated into the soil. Increased water holding capacity and organic matter has a positive effect on site productivity. The increased soil productivity does not necessarily equal the soil productivity lost in the cut portion of the road. On an acre basis, we can estimate that approximately 50% of a new temporary road will experience detrimental soil disturbance. The road surface is compacted by equipment travel during the construction process as well as from log truck travel on the road. Road soil compaction is a long-term effect. The increased soil bulk density (due to compaction processes) will slowly lessen as plant roots and other biological components reoccupy the road surface. It has been reported that bulk density recovery in the upper 6 inches of logging roads in North Carolina was estimated to take 40-60 years (Drissi, 1975; Perry, 1964). This Alternative proposes to construct 1.7 miles of new temporary roads. Converting these road miles to acres results in 7.7 acres.

Summary

Overall, the Preferred Alternative has a high probability of meeting the six soil resource standards and guidelines. The main areas of concern are ground-based mechanical logging (1,056 acres), and machine mastication (1,030 acres). Mechanical ground-based logging can result in soil compaction that exceeds Soil Quality Analysis Standards (SQAS) but this only occurs on highly used main skid trails when soils are moist and to a much lesser degree in cable corridors. Overall, the amount of ground that is in highly used main skid trails and cable corridors that exceeds the SQAS detrimental disturbance standards would be below the 15% threshold value for all units except units 220, 234, 332, 342, 343, 368, 709 and 756. Units 332 and 343 currently exceed the 15% detrimental disturbance threshold. Eight of the nine of the units will have their main skid trails subsoiled (on slopes <35%). Unit 332 will be helicopter logged, which will not measurably contribute to cumulative effects. Mastication of organic materials can increase the thickness of the surface litter layer, reduce soil temperatures by 4-5 degrees C and reduce evapotranspiration by 15-86%. This alternative, with post-logging remedial actions in units 220, 234, 342, 343, 368, 709 and 756 will meet the LRMP and SQAS guidelines for soil cover, porosity, soil organic matter content, surface organic matter levels, soil moisture regime, soil hydrologic function, buffering capacity and maintain a well functioning soil biological system. Overall, this alternative will maintain both short and long-term soil productivity.

INDIRECT EFFECTS

Indirect effects on the soil ecosystem are secondary reactions to direct effects. The most common secondary reactions are increased surface erosion (from ground disturbance, soil cover removal), reduction in fertility (compaction, removal of fine organic materials), and reduced vegetative growth (compaction, loss of fine organic materials).

Ground-based mechanical yarding would cause a loss of nutrients in the skid trails due to soil displacement and skid trail erosion. Soil erosion on skid trails can vary from 1.1 to 4.1 tons/acre depending on soil cover. This is equivalent to 26-98 pounds of soil erosion per segment of skid trail (A segment is the area between two water bars.). Reduced soil porosity would reduce growth of any trees and other vegetation that would grow on these skid trails, post-harvest. Installing water bars on all skid trails is very effective in controlling runoff and preventing off-site sedimentation. Recent BMP monitoring of skid trails revealed that water bars were very effective in controlling erosion and preventing sediment from reaching a stream course. Monitored water bars were 96-100% effective (KNF, 2000-2007). The high amounts of soil cover (80-90%) in non-skid trail areas will act as sediment filters and prevent skid trail derived sediment from reaching a drainage channel. Mitigation measures pertaining to skid trails are designed to minimize erosion.

Cable yarding would result in an estimated 3 to 8% additional disturbance of the area within a unit being disturbed depending on the diameter of trees removed. There will be a loss of nutrients and soil organic matter in the drastically disturbed portion of the corridor. The amount of reduced soil productivity would be measurable within the more drastically disturbed portion of the corridor but would not be measurable on an acre bases due to the narrow size of the disturbance. This amount of area with reduced soil productivity is within the Region's and Forest's guidelines which is 15% of the activity area. Installing water bars on all cable corridors is very effective in controlling runoff and preventing off-site sedimentation.

Helicopter yarding would cause a slight insignificant loss of nutrients where the trees fall or if trees slide down slope.

Landings usually are disturbed sites that have significant lower site productivity due to compaction and loss of nutrients. There will be a change in the types of vegetation grown on these sites, more towards grass and brush with stunted trees slowly reoccupying these sites. Rehabilitation of non-road prism landings as described in the mitigation measures will minimize short and long-term erosion. Erosion that moves off the landing would be filtered out by the high levels of soil cover retained in the areas immediately adjacent to the landings.

Hand piling and subsequent burning of the piles could occupy up to 25% of the hand piled acres. The nutrient loss from the burned pile area would have a minor to no measurable effect on soil productivity (loss of nitrogen). Other nutrients, such as cations, will increase in the soil due to leaching. Soil erosion would be minimal (<0.8 tons/acre) to insignificant due to the mosaic nature of the burn piles and high percentage of area with an intact duff layer. Delivered sediment from the piled area would be insignificant to none. The soil biota in the burned pile areas would be reduced by the effects of heat but would quickly recover as litter fall adds fine organic matter to the soil surface and soil micro-organisms re-invade these small sites (Borchers and Perry, 1990).

Machine mastication will have some effects on vegetative biomass production by causing some ground disturbance and possibly a small amount of area with decreased porosity. Overall, this treatment increases ground cover thickness, reduces soil temperature, decreases evapotranspiration and increases onsite fine organic matter with only minimal ground disturbance when done during dry soil conditions. Soil erosion would vary from 130 to 364 pounds/acre) with sedimentation being very low (13 to 36 pounds/acre) due to the high soil cover and untreated buffer areas. Microbial biomass would probably be increased due to maintaining soil temperatures and soil moisture by retention of surface materials (Borchers and Perry, 1990). Site fertility will slowly increase as masticated organic material decomposes and increases site nutrients.

Underburning in harvested and nonharvested areas would not disturb additional soil. Heat penetration into the surface soil during burning will be minimal to none. Generally, soil pH, P, and exchangeable K, Ca, and Mg increase in the soil immediately after fire (Wells et al., 1979). Also, some of the seedbed in isolated spots may be disturbed and cause less vegetative growth over the short term. Erosion will be minimal to none because this low intensity burn will retain sufficient cover to protect the soil (Laurent, 2007).

Precommercial thinning by hand operated chainsaws will have no measurable negative effects on vegetative biomass production due to little or no ground disturbance. This minor reduction in biomass production would be offset by increased growth on the retained trees. Overall, this treatment increases ground cover thickness, reduces soil temperature, decreases evapotranspiration and increases onsite fine organic matter with only minimal ground disturbance when done during dry soil conditions. Potential soil erosion would be minor to none with sedimentation being insignificant to none due to the high soil cover and untreated buffer areas. Microbial biomass would probably be increased due to maintaining soil temperatures and soil moisture by retention of surface materials (Borchers and Perry, 1990). Site fertility will increase as masticated organic material decomposes and increases site nutrients.

CWD would experience some loss of function when the more decomposed logs are disturbed from heavy equipment use. Increases in CWD from this project and through time will benefit long-term soil productivity.

Road maintenance/upgrade reduces road related erosion by fixing road drainage problems such as rills and gullies, redirects runoff to dips and replaces undersized culverts.

Temporary road construction alters soil health (biological functionality) in the cut portion of the road and is less altered in the fill portion of the road. Soil health gradually recovers over the long-term as trees become established in the road bed and fill slopes. This change in soil health has a low potential to negatively affect the surrounding site. At a minimum, 50% of the road acres (2 acres) would experience a long-term reduction in soil productivity. The other 50% of the road acres would experience some level of increased site productivity, mainly by an increased water holding capacity (increased soil depth). Road related erosion from new temporary road construction is calculated to be 5.7 yds^3. This is the calculated sedimentation if these roads stay open through one winter before hydrologic decommissioning. If some or all of these roads are hydrologic decommissioned before the onset of the first winter, sediment production would be substantially reduced.

Soil Erosion

Soil erosion in undisturbed soils is mostly as chemical erosion from rainwater leaching through the soil. Soil erosion on exposed soil in mountainous terrane, can be difficult to see to the casual observer. Surface erosion equal to the thickness of a single sheet of paper (0.004 inches) is equivalent to 0.63 tons/acre (1,260 pounds) of erosion. Average soil formation from bedrock as reported by Alexander (1988) is about 1.0 tons/acre/year. Sheet erosion equal to 2 sheets of paper in thickness, exceeds this reported soil formation rate, yet this is for the most part unobservable erosion.

Soil erosion in the Klamath Mountains is primarily sheet erosion, which consists of raindrop splash displacement of soil particles and subsequent down slope deposition of this dislodged material. Raindrop splash is the result of water drop impact forces, where a raindrop falling on an exposed wetted soil surface dislodges soil particles. Detached soil particles travel in a parabolic curve, moving laterally about four times their height (Thornes, 1980) and splash in a down slope direction. Detached soil particles usually move very short distances downslope due to obstructions such as organic cover materials. Rilling occurs when overland flow concentrates.

Table 2 shows soil erosion rates for the No Action, No Action + wildfire and Preferred Alternatives. The data shows that the No Action Alternative and Preferred Alternatives have the least erosion and the No Action + wildfire Alternative has the highest erosion rate. Overall, erosion rate for the Preferred Alternative does not exceed the average soil formation rate as required by the SQAS.

Table 2. Range of USLE surface erosion data (mobilized, not delivered)

Alternative	Pre-project pounds/acre	Post-project pounds/acre	Standard pounds/acre
No Action	220-260	220-260	2000
No Action+Wildfire	220-260	220-30,000	2000
Preferred	220-260	500	2000

Summary

Overall, the Preferred Alternative has a high probability of meeting the six soil resource standards and guidelines and therefore, maintaining short and long-term soil productivity. The main areas of concern are ground-based yarding systems and machine mastication. Mechanical ground-based logging can result in increased soil erosion and reductions in soil productivity (compaction and soil displacement), primarily in main skid trails. Post-logging mastication of organic debris will provide adequate soil cover over the project area. The mastication process spreads the masticated material over the soil surface and disperses the material a few to many feet to the front and sides of the machine. This will increase the cover on the main skid trails and some cable corridors with slopes less than 35%. Treatment of existing and activity fuels would adequately reduce the wildfire risk. This alternative will meet the LRMP and SQAS guidelines for soil erosion and fertility. Overall, this alternative will maintain short and long-term soil productivity.

CUMULATIVE EFFECTS

Cumulative effects on the soil ecosystem are based on the number and types of management activities occurring within an individual stand over time and are measured by effects on soil productivity. In general, effects on soil productivity are site specific and not spatially mobile over the analysis area.

Table 3 displays the cumulative effects of Alternatives 2, 4, 5 and the Preferred Alternative on the soil resource by management activity. Alternatives 2, 4 and 5 are included in this Table because some of the data has been recalculated and this Addendum corrects the values presented in the project Soil Report. This table shows that effects of the logging systems do not exceed their allowable 15% threshold value. In addition, the overall total value for the Preferred Alternative is 7.8%, which is well below the 15% threshold for detrimental disturbance.

Appendix Table 7 displays the existing cumulative effects from past logging, the estimated cumulative effects for each management unit associated with this project and the expected cumulative detrimental disturbance as a percent. The values range from 1-24% and averages 7.2%. The data in Appendix Table 7 shows that existing + predicted detrimental cumulative effects in units 220, 234, 332, 337, 342, 343, 366, 368, 709, 756 and 757 are near or exceed the SQAS 15% threshold value (14-24%).

Table 3. Allowable and Cumulative Soil Productivity Loss per LRMP Guidelines

Logging System	Alt. 2	Alt. 4	Alt. 5	Preferred Alt
Ground-based (Tractor and mechanical harvester)	180/110[1]	148/96[1]	163/110[1]	158/97[1]
Skyline	240/102[1]	232/104[1]	221/101[1]	242/106[1]
Helicopter	161/61[1]	127/42[1]	183/65[1]	140/55[1]
Temp Roads (new+existing)	59	55	50	48
Landings (new+existing)	43	41	39	40
RR Treatments (existing)	33	33	33	33
Underburn units (existing+new)	7	7	7	87
Mastication (existing+new)	3	3	3	3
TOTAL	**418**	**381**	**408**	**469**
Acres disturbed/total acres within harvest units, burn areas, temp rds and landings	**10.2%**	**10.7%**	**10.2%**	**9.1%**

1. Allowable/cumulative: The first number is the LRMP's 15% threshold acre value for detrimental soil conditions and the second number is the cumulative (existing+predicted) acres of detrimental soil disturbance.

Units 332, 366 and 757 have a low potential to have additional cumulative effects on the soil resource due to being helicopter logged with this alternative. Units 220, 234, 342, 368, 709 and 756 have a high potential to have cumulative effects on the soil resource due to being logged with ground-based logging systems and having an estimated current detrimental disturbance level of 14-16%. Unit 343 currently exceeds the 15% threshold and is expected to further exceed the soil porosity standards due to planned ground-based mechanical logging. Units 220, 234, 342, 343, 368, 709 and 756 will have their main skid trails subsoiled in order to lower their detrimental cumulative effects to below the 15% detrimental disturbance threshold. The generally low intensity of planned harvesting (thinning) and fuel reduction activities will minimize cumulative effects on nutrient cycling by minimizing the consumption of the fine organic component (duff mat).

The machine mastication and hand piling, and burning of the hand piles will have no long-term cumulative effects on soil erosion, nutrient availability, and soil productivity. These types of fuel treatments will not expose excessive amounts of soil and will have minimal effects on the soil resource since existing down materials would not be treated. The combination of past and planned activities will have small short-term negative effects on short-term soil productivity that will not be measurable on a stand basis (volume of biomass produced). Long-term soil productivity will be maintained.

Erosion

Current soil erosion rates for the project acres are approximately 220-260 pounds/acre and averages 240 pounds/acre.

The Preferred Alternative will increase surface erosion rates in the treated acres to an average of 500 pounds/acre. The 500 pounds/acre of soil erosion equates to 0.0016 inches of surface soil which is approximately 4.0 times smaller than the SQAS standard erosion rate.

The effect of this calculated increased soil erosion on short and long-term soil productivity is none to slight. Slight to none would not be measurable when using total soil nitrogen lost or reductions in biomass volume produced.

Summary of Cumulative Effects

Overall, The Preferred Alternative has a high probability of meeting the six soil resource standards and guidelines and therefore, maintaining short and long-term soil productivity. The main areas of concern are the ground-based logging acres. The reuse of existing skid trails will minimize areas of new compaction and minimize the cumulative effects of multi-harvest entries. Currently, existing detrimental soil disturbance ranges from 0-21% and averaged from 4.8% for the project area as determined primarily in the ground-based logging acres. Ground-based logging units that are near or exceed the detrimental disturbance threshold will have their main skid trails subsoiled. Subsoiling will lower their detrimental disturbance levels to below the detrimental disturbance threshold. On a project basis, the cumulative effects of past harvesting and the proposed project will meet the SQAS detrimental disturbance standard by not significantly decreasing short or long-term soil productivity. Overall, this alternative will meet the LRMP and SQAS guidelines for maintaining long-term soil productivity.

CWE Model – USLE Component

Cumulative Effects displayed in the USLE model (Table 10) reflect short term risk of increased erosion related to ground disturbance, prescribe fire and wildfire. The model outputs should be viewed as reasonable estimates rather than absolute values. The relative difference between alternative risk ratios is a better method of evaluating alternatives compared to looking at just the increased risk ratio or of the risk ratio being above or below the inference point (1.00). This is because the model has numerous assumptions that overestimate erosion, such as the delivery coefficient, soil cover values and timing of management activities.

The model assumes that 10% of the calculated surface erosion is delivered to a drainage channel regardless of slope position, surface geomorphic shape (dispersion or concentration of runoff) and undisturbed stream buffer filters. Recent work on the Klamath National Forest in Grouse and Beaver Creeks by Cover et al. (2008) showed that sediment supply (USLE calculated erosion) was well correlated with measured streambed fine sediment scaled by stream power when using a 5% sediment delivery factor rather than the current 10% delivery factor.

The USLE model values (Bousfield et al., 2008) assumed 70% cover retained for tractor thinned areas with underburning, 80% cover for cable thinned areas with underburning and 85% cover for helicopter thinned areas with underburning. The Forest's soil cover monitoring data (Laurent, 2007) show that the soil cover values used in the model underestimates the actual soil cover values. Soil cover monitoring data for tractor logged areas with underburning averaged 85% soil cover (range: 66-98%). Soil cover monitoring data for cable logged areas with underburning averaged 80% soil cover (range: 56-98%) and 90% cover without underburning. Soil cover monitoring data for helicopter logged areas with underburning averaged 83% soil cover (range: 82-83%). The above cover data shows that the model overestimates erosion from tractor logged areas and is representative for cable and helicopter logged areas. In addition, Forest monitoring data showed that on average 28% (range: 6-65%) of the area within underburn perimeters remains unburned. The USLE model cover values do not reflect this fact. Therefore the USLE calculated erosion values for underburning overestimate surface erosion rates by also not considering how much area is left in an unburned condition.

The USLE model assumes that all logging and burning is completed in one season. In reality, the logging will take a number of years to complete as well as the underburning. It is estimated by the District that approximately 500-800 acres could be underburned during any one year. So the effects of burning would be spread over 3 to 5 years without factoring in the timing of logging the units that would allow the areas to be burned. The modeled values do not reflect this timeframe.

Basically, the USLE output values are over-estimated from the sediment delivery rate (10% rather than 5%), from not factoring in the 28% of underburn areas that don't burn, lower cover values for ground-based logged units + underburning as well as assuming all work is one in one year. The relative difference (percent change) between risk ratios is a better method of evaluating alternatives compared to looking at just the increased risk ratio or of the risk ratio being above or below the inference point (1.00). The model outputs should be viewed as reasonable estimates rather than absolute values.

USLE Risk Ratios

Table 10 displays the USLE model results as risk ratios. Risk ratios represent the ratio of existing conditions (past logging + wildfire + roads) relative to 400% over background conditions. The 400% over background erosion rates represents the inference point where sediment volumes become a cause for concern. Risk ratios only reflect changes in watershed conditions from logging and wildfire. Impacts to watershed conditions from floods and post-flood conditions are not reflected in the USLE background value. Background conditions assumes undisturbed forested conditions and not damaged conditions such as the head of Grouse

Creek where past overgrazing of dry meadows has created bare soil conditions. Also, surface erosion from inner gorge areas that have been stripped of vegetation due to a flood or bare debris slide areas is not added into the background sediment levels with the USLE model. With this model, a higher background value will calculate a smaller risk ratio.

Table 10 also displays the percent increase in risk ratios above background conditions. The percent increase in risk ratios for individual 7th field watersheds ranges from 0 to 11.4% for the Preferred Alternative. Hungry Creek 7th field watershed is the only watershed that is currently over its inference point. The Preferred Alternative does not affect this watershed. Beaver-Grouse and Deer-Beaver 7th field watersheds are currently below their respective inference points. The Preferred Alternative, assumed logged and underburned in one year, would raise Beaver-Grouse and Deer-Beaver risk ratios by 9.6% and 8.5%, respectively. These values are 3 and 2% above the inference point. In reality, not all harvesting will occur in one year and the underburning would probably occur when logging is completed. Assuming that a third of the units are logged in any one year, the risk ratios would be approximately 0.97 and 0.96 for Beaver-Grouse and Deer-Beaver, respectively.

Summary of CWE/USLE Model

Risk ratios for Beaver-Grouse and Deer-Beaver Creek 7th field drainages range from 0.1 to 0.3 over the 1.0 threshold value (Bousfield et al., 2007). This is a very small increase over threshold values and well within the margin of error for this model. Assuming that the logging is spread out over 3-5 years and most of the burning occurs after logging is complete, the risk ratios for the 7th field watersheds with proposed management activities, would be less than 1.0.

In addition, factoring in the higher USLE output values from not factoring in the 28% of underburn areas that don't burn and lower cover values for ground-based logged units + underburning would also lower the risk ratios. The model outputs should be viewed as reasonable estimates rather than absolute values.

V SIGNIFICANCE FACTORS

Appendix Table 8 displays the 10 intensity factors and their applicability to the soil resource for the Proposed Alternative.

VI MONITORING

Post-project monitoring, as part of the Forest's soil program, would be done to evaluate how well the project met the SQAS and LRMP soil guidelines. Three units (234, 343, 756) logged with ground-based harvest systems will be selected for SQAS compliance monitoring (% area in skid trails + landings, porosity changes in skid trails). Three subsoiled units would be monitored (220, 342, 368). Three mastication and one hand pile units would be monitored for soil cover, disturbance and soil porosity changes. This monitoring will be combined with the post-logging monitoring of units 332, 343 and 366.

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XI. APPENDIX TABLES

Table 4. Existing soil information for selected vegetation management units.

Unit No.	Range of Existing soil Cover %	Existing Total Soil Cover (average) %	Existing Erosion Hazard Rating	Existing Detrimental Disturbance %
205	90-100	99	Low	5
218	90-100	99	Low	0
220	20-100	93	Low	11
225	25-100	89	Low	10
227	90-100	98	Low	0
228	50-100	96	Low	0
230	35-100	93	Low	2
233	35-100	95	Low	9
234	50-100	97	Low	13
237	40-100	91	Low	4
240	25-100	96	Low	3
243	40-100	96	Low	2
247	40-100	98	Low	4
252	25-100	96	Low	5
268	25-100	92	Low	1
271	60-100	97	Low	7
276	90-100	99	Low	2
279	90-100	98	Low	1
286	15-100	90	Low	8
287	90-100	99	Low	2
288	30-100	95	Low	1
297	90-100	98	Low	5
315	70-100	95	Low	3
316	40-100	95	Low	5
324	30-100	83	Low	5
332	25-100	84	Low	19
333	80-100	98	Low	8
335	70-100	99	Low	2
337	30-100	79	Low	12

Table 4. Continued

Unit No.	Range of Existing soil Cover %	Existing Total Soil Cover (average) %	Existing Erosion Hazard Rating	Existing Detrimental Disturbance %
338	90-100	98	Low	9
341	50-100	91	Low	5
342	90-100	99	Low	12
343	60-100	96	Low	21
349	90-100	98	Low	0
350	70-100	95	Low	10
351	95-100	98	Low	6
359	25-100	96	Low	3
360	80-100	97	Low	4
361	70-100	97	Low	3
366	35-100	84	Low	13
368	35-100	86	Low	11
380	25-100	87	Low	8
383	35-100	96	Low	2
390	90-100	99	Low	0
392	90-100	98	Low	3
399	30-100	91	Low	0
412	90-100	99	Low	5
414	45-100	80	Low	0
432	90-100	99	Low	5
434	60-100	95	Low	2
438	30-100	92	Low	0
700	30-100	81	Low	2
701	30-100	81	Low	2
702	30-100	81	Low	2
704	50-100	95	Low	6
705	50-100	95	Low	6
706	45-100	95	Low	6
707	45-100	95	Low	6
708	45-100	95	Low	6
709	65-100	85	Low	12
710	65-100	85	Low	12
711	65-100	93	Low	4
712	65-100	93	Low	4

Table 4. Continued

Unit No.	Range of Existing soil Cover %	Existing Total Soil Cover (average) %	Existing Erosion Hazard Rating	Existing Detrimental Disturbance %
713	15-100	93	Low	2
714	15-100	93	Low	2
716	25-100	94	Low	1
717	25-100	95	Low	5
718	25-100	95	Low	5
719	25-100	95	Low	5
720	50-100	96	Low	3
721	50-100	96	Low	3
722	50-100	96	Low	3
723	30-100	95	Low	5
724	30-100	95	Low	5
725	30-100	95	Low	7
726	30-100	95	Low	7
727	30-100	95	Low	7
728	30-100	95	Low	7
729	30-100	95	Low	7
730	30-100	95	Low	7
731	55-100	96	Low	2
732	55-100	96	Low	2
733	30-100	95	Low	2
734	30-100	95	Low	2
735	30-100	95	Low	2
736	30-100	95	Low	8
737	30-100	95	Low	8
738	30-100	92	Low	2
739	30-100	92	Low	2
740	60-100	95	Low	3
741	60-100	95	Low	3
742	90-100	98	Low	9
743	90-100	98	Low	9
744	40-100	87	Low	6
745	40-100	87	Low	6
746	50-100	93	Low	9
747	50-100	93	Low	9
748	50-100	94	Low	0

Table 4. Continued

Unit No.	Range of Existing soil Cover %	Existing Total Soil Cover (average) %	Existing Erosion Hazard Rating	Existing Detrimental Disturbance %
749	50-100	94	Low	0
750	90-100	97	Low	1
751	90-100	97	Low	1
752	60-100	97	Low	1
753	60-100	97	Low	1
754	60-100	97	Low	1
755	60-100	97	Low	1
756	45-100	95	Low	13
757	45-100	95	Low	13
759	20-100	82	Low	3
760	20-100	82	Low	3
761	70-100	89	Low	0
762	70-100	89	Low	0
763	30-100	95	Low	2
764	30-100	95	Low	2
765	30-100	95	Low	2

Existing detrimental disturbance is disturbance that exceeds Regional SQAS regarding compaction and loss of soil organic matter; Data gathered by Tom Laurent during field investigations of the project area in 2004 and 2006

Table 5. Existing slope data for selected units

Unit No.	Log. System	Range in Slopes %	Average Slopes %	Area of unit with ≤35% slopes %	Area of unit with 36-49% slopes %	Area of unit with >50% slopes %
205	H	20-65	44	14	50	36
218	S	20-45	34	64	36	-
220	T	17-47	33	60	40	-
225	S	2-45	20	96	4	-
227	S	35-66	53	9	18	73
228	S	30-68	50	6	41	53
230	S	10-70	45	29	29	42
233	CGB	2-50	17	90	8	2
234	T	2-37	18	97	3	-
237	S	12-50	31	67	28	5
240	T	7-48	27	89	11	-
243	S	15-63	35	51	46	2
247	CGB	1-47	22	78	22	-
252	-	3-58	28	72	22	6
268	T/TE	25-63	46	24	31	45
271	CGB	15-55	31	65	31	4
276	T	7-50	33	44	50	6
279	H	18-60	42	20	60	20
286	T	3-50	21	82	15	3
288	H	6-60	38	37	43	20
315	CGB	19-43	34	53	47	-
316	H	18-46	28	88	12	-
324	T	15-43	31	69	31	-
332	H	27-48	36	42	58	-
333	H	23-53	41	30	40	30
335	CGB	10-60	36	45	38	17
337	TE	27-61	45	8	60	32
338	T	8-32	22	100	-	-
341	MH	10-40	20	97	3	-
342	MH	5-39	15	90	10	-
343	T	5-37	20	93	7	-

Table 5 continued.

Unit No.	Log System	Range in Slopes %	Average Slopes %	Area of unit with ≤35% slopes %	Area of unit with 36-49% slopes %	Area of unit with >50% slopes %
349	T	15-43	27	83	17	-
350	S	24-65	41	30	40	30
351	S	17-32	22	100	-	-
359	S	13-55	32	59	32	9
360	S	20-38	28	93	7	-
361	H	12-45	29	78	22	-
366	H	9-58	38	38	59	3
368	T	1-45	19	95	5	-
380	CGB	5-53	30	65	33	2
383	S	5-62	33	61	26	13
390	H	30-55	43	13	74	13
392	S	25-52	41	25	56	19
399	H	22-53	38	47	40	13
412	H	20-65	44	14	50	36
414	S	40-60	51	-	23	77
438	S	28-63	49	10	35	55
700	T	12-55	33	62	33	5
701	T	12-55	33	62	33	5
702	T	18-47	32	56	44	-
704	T	5-62	35	40	48	12
705	S	5-62	35	40	48	12
706	T	8-48	27	75	25	-
707	H	19-48	32	56	44	-
708	CGB	8-45	24	86	14	-
709	T	23-45	33	60	40	-
710	H	23-45	33	60	40	-
711	T	3-45	24	78	22	-
712	S	3-45	24	78	22	-
713	S	3-54	29	70	27	3
714	CGB	3-54	29	70	27	3
716	CGB	8-53	33	61	32	7
717	T	10-45	26	90	10	-

Table 5 continued.

Unit No.	Log System	Range in Slopes %	Average Slopes %	Area of unit with ≤35% slopes %	Area of unit with 36-49% slopes %	Area of unit with >50% slopes %
718	S	11-49	32	65	35	-
719	H	30-45	38	30	70	-
720	S	19-44	30	80	20	-
721	T	20-41	33	69	31	-
722	T	17-47	28	92	8	-
723	T	1-52	33	63	32	5
724	S	15-52	32	57	36	7
725	CGB	4-50	24	80	13	7
726	S	26-50	37	50	25	25
727	H	16-56	38	43	43	14
728	T	15-55	33	63	25	12
729	H	4-56	29	72	20	8
730	S	4-56	29	72	20	8
731	S	8-65	41	38	31	31
732	CGB	8-65	41	38	31	31
733	CGB	2-38	18	95	5	-
734	H	2-38	18	95	5	-
735	S	2-38	18	95	5	-
736	H	2-49	30	60	40	-
737	H	2-49	30	60	40	-
738	CGB	15-65	33	65	29	6
739	H	15-65	33	65	29	6
740	T	8-43	22	84	16	-
741	S	25-47	33	71	29	-
742	S	15-47	35	54	46	-
743	T	15-55	29	72	17	11
744	S	7-55	32	75	19	6
745	T/TE	7-55	32	75	19	6
746	T	22-29	25	100	-	-
747	H	27-42	36	33	67	-
748	MH	2-13	8	100	-	-
749	T	20-59	34	60	20	20
750	TCGB	3-19	11	100	-	-
751	T	16-45	29	94	6	-
752	T	9-55	34	53	36	11
753	CGB	9-55	35	52	40	8

Table 5 continued.

Unit No.	Log System	Range in Slopes %	Average Slopes %	Area of unit with ≤35% slopes %	Area of unit with 36-49% slopes %	Area of unit with >50% slopes %
754	T	9-55	35	52	40	8
755	S	9-55	35	52	40	8
756	T	9-62	31	72	18	10
757	H	9-62	31	72	18	10
759	T/H	2-53	31	50	40	10
760	T/H	2-53	33	51	44	5
761	T	5-55	35	46	42	12
762	S	5-55	35	46	42	12
763	S	5-60	39	38	44	18
764	S	5-60	39	38	44	18
765	TE	5-60	47	23	31	46

CGB: combined ground based systems (mechanical harvester and tractor);
H: helicopter
S: skyline cable system
T: conventional tractor yarding

Table 6. Existing CWD Decomposition Class and Distribution throughout selected treatment units.

≥20 inch diameter CWD

Harvest Unit No.	**Existing CWD ≥20 in. logs/acre**	**CWD Decomposition Class 1 %**	**2 %**	**3 %**	**4 %**	**5 %**
205	6.9	-	16	17	50	17
220	5.3	-	25	75	-	-
225	5.3	-	17	66	17	-
227	5.3	-	-	-	-	-
228	2.4	-	-	-	-	-
230	3.4	-	-	-	-	-
233	3.1	-	20	-	80	-
234	6.5	-	11	56	22	11
237	1.3	-	-	-	-	100
240	6.0	-	22	33	33	12
243	1.2	-	-	100	-	-
247	3.1	-	-	60	40	-
268	1.5	-	-	-	50	50
271	4.6	-	75	25	-	-
286	5.3	-	36	21	29	14
287	8.0	-	-	20	80	-
297	8.0	-	17	41	25	17
311	0	-	-	-	-	-
332	6.0	-	-	67	-	33
333	0	-	-	-	-	-
337	4.0	-	50	25	25	-
338	8.0	-	-	83	17	-
342	8.0	-	-	-	67	33
343	2.4	-	-	33	33	34
350	12.0	-	50	33	17	-
351	8.0	-	-	-	100	-
359	8.0	-	-	33	67	-
360	6.4	-	-	50	50	-
361	8.0	-	71	29	-	-
368	4.0	-	17	66	-	17

Data gathered by Tom Laurent during field investigations of the project area in 2004 and 2006

Table 6. Continued.

≥20 inch diameter CWD

Harvest Unit No.	Existing CWD ≥20 in. logs/acre	CWD Decomposition Class 1 %	2 %	3 %	4 %	5 %
383	5.9	-	32	36	20	12
412	6.9	-	16	17	50	17
414	2.0	-	-	100	-	-
432	3.0	-	-	100	-	-
438	5.7	-	-	20	60	20
700	3.0	-	-	38	50	12
701	3.0	-	-	38	50	12
702	3.0	-	-	38	50	12
706	9.1	-	-	75	25	-
707	9.1	-	-	75	25	-
708	9.1	-	-	75	25	-
711	6.4	-	50	25	-	25
712	6.4	-	50	25	-	25
716	4.6	-	17	50	25	8
717	2.5	-	-	75	25	-
718	2.5	-	-	75	25	-
719	2.5	-	-	75	25	-
723	4.9	-	9	55	36	-
724	4.9	-	9	55	36	-
725	3.7	-	-	50	50	-
726	3.7	-	-	50	50	-
727	3.7	-	-	50	50	-
728	3.7	-	-	50	50	-
729	3.7	-	-	50	50	-
730	3.7	-	-	50	50	-
731	4.0	-	-	83	17	-
732	4.0	-	-	83	17	-
744	6.4	-	-	75	25	-
745	6.4	-	-	75	25	-
746	6.4	-	-	75	25	-
747	6.4	-	-	75	25	-

Data gathered by Tom Laurent during field investigations of the project area in 2004 and 2006

Table 6. Continued

$\geq$20 inch diameter CWD

Harvest Unit No.	Existing CWD $\geq$20 in. logs/acre	CWD Decomposition Class 1 %	2 %	3 %	4 %	5 %
748	2.7	-	100	-	-	-
749	2.7	-	100	-	-	-
763	3.2	-	12	63	25	-
764	3.2	-	12	63	25	-
765	3.2	-	12	63	25	-

Data gathered by Tom Laurent during field investigations of the project area in 2004 and 2006

Table 7. Cumulative effects for each harvest unit.

Unit No.	Acres	Logging system	Existing Detrimental Disturbance %	Detrimental Disturbance Threshold @15% acres	Cumulative Detrimental Disturbance acres	Cumulative Detrimental Disturbance %
202	7	S	3	1.0	0.4	6
204	73	S	3	11.0	4.7	6
205	4	H	5*	0.6	0.2	5
206	55	S	3	8.3	3.6	7
207	34	S	3	5.1	2.2	6
212	13	S	3	2.0	0.9	7
213	92	H	5	13.8	5.1	6
216	51	S	3	7.7	3.3	6
218	4	S	0*	0.6	0.1	1
220	4	T	11*	0.6	0.6	15
223	3	S	3	0.5	0.2	7
224	4	T	5	0.6	0.3	8
225	15	S	10*	2.3	2.0	13
227	10	S	0*	1.5	0.3	3
228	91	S	0*	13.7	2.7	3
230	30	S	2*	4.5	1.5	5
232	18	S	3	2.7	1.2	7
233	57	CGB	9*	8.6	6.8	12
234	40	T	13*	6.0	6.4	16
236	6	S	3	0.9	0.4	7
237	33	S	4*	5.0	2.3	7
240	20	T	3*	3.0	1.2	6
243	33	S	2*	5.0	1.7	5
247	23	CGB	4*	3.5	1.6	7
252	134	-	5*	20.1	6.7	5
253	133	S	3	20.0	8.6	6
254	37	S	5	5.6	3.1	8
255	12	S	3	1.8	0.8	7
256	11	S	3	1.7	0.7	6
261	75	H	5	11.3	4.2	6
262	20	S	3	3.0	1.3	7
266	26	S	3	3.9	1.7	7
267	50	H	5	7.5	2.8	6
268	10	T/TE	1*	1.5	0.4	4
270	21	H	5	3.2	1.2	6

* estimated from field data

Table 7. Continued

Unit No.	Acres	Logging system	Existing Detrimental Disturbance %	Detrimental Disturbance Threshold @15% acres	Cumulative Detrimental Disturbance acres	Cumulative Detrimental Disturbance %
271	7	CGB	7*	1.1	0.7	10
272	25	S	3	3.8	1.7	7
274	6	H	5	0.9	0.4	7
276	1	T	2*	0.2	0.05	5
277	88	S	3	13.2	5.7	6
278	18	S	3	2.7	1.2	7
279	8	H	1*	1.2	0.1	1
284	21	S	3	3.2	1.4	7
286	47	T	8*	7.1	5.1	11
287	7	T	2*	1.1	0.3	4
288	45	H	1*	6.8	0.7	2
289	36	H	5	5.4	2.0	6
290	17	H	5	2.6	0.9	5
291	19	H	5	2.9	1.1	6
295	5	H	6	0.8	0.3	6
296	27	H	5	4.1	1.5	6
297	12	CGB	5*	1.8	1.0	8
300	58	S	3	8.7	3.7	6
315	5	CGB	3*	0.8	0.3	6
316	8	H	5*	1.2	0.4	5
320	70	H	3	10.5	2.5	4
321	24	H	5	3.6	1.3	5
324	7	T	5*	1.1	0.6	9
327	5	T	5	0.8	0.6	12
328	4	S	3	0.6	0.3	8
330	34	H	5	5.1	1.9	6
331	31	H	5	4.7	1.8	6
332	24	H	19*	3.6	4.7	20
333	18	H	8*	2.7	1.5	8
335	5	CGB	2*	0.8	0.3	6
337	24	TE	12*	3.6	3.4	14
338	26	T	9	3.9	3.0	12
340	9	T/TE	5	1.4	0.8	9
341	23	MH	5*	3.5	1.8	8

*estimated from field data

Table 7. Continued

Unit No.	Acres	Logging system	Existing Detrimental Disturbance %	Detrimental Disturbance Threshold @15% acres	Cumulative Detrimental Disturbance acres	Cumulative Detrimental Disturbance %
342	24	MH	12*	3.6	3.6	15
343	34	T	21*	5.1	8.1	24
345	8	S	3	1.2	0.5	6
346	1	T	5	0.2	0.1	10
347	17	S	5	2.6	1.4	8
349	3	T	0*	0.5	0.1	3
350	3	T	10*	0.5	0.4	13
351	5	S	6*	0.8	0.5	10
353	1	T	6	0.2	0.1	10
359	15	S	3*	2.3	0.9	6
360	12	S	4*	1.8	0.9	8
361	7	H	3*	1.1	0.3	4
366	8	H	13*	1.2	1.1	14
367	17	H	5	2.6	1.0	6
368	37	T	11*	5.6	5.2	14
372	9	H	5	1.4	0.6	7
373	17	H	4	2.6	0.8	5
374	9	S	6	1.4	0.8	9
375	14	S	5	2.1	1.1	8
377	13	S	3	2.0	1.2	9
378	30	S	3	4.5	2.8	9
380	55	CGB	8*	8.3	6.0	11
381	37	S	5	5.6	3.0	8
383	56	S	2*	8.4	2.8	5
384	3	S	3	0.5	0.2	7
386	9	H	5	1.4	0.5	6
387	12	T	7	1.8	1.1	9
390	8	H	0*	1.2	0.04	1
392	7	S	3*	1.1	0.4	6
393	7	H	5	1.1	0.4	6
394	50	H	7	7.5	3.8	8
397	2	H	5	0.3	0.1	5
398	16	S	6	2.4	1.4	9
399	4	H	0*	0.6	0.02	1
400	19	S	3	2.9	1.2	6
401	20	H	4	3.0	0.9	5
403	30	S	5	4.5	2.4	8
405	12	S	4	1.8	0.8	7

*estimated from field data

Table 7. Continued

Unit No.	Acres	Logging system	Existing Detrimental Disturbance %	Detrimental Disturbance Threshold @15% acres	Cumulative Detrimental Disturbance acres	Cumulative Detrimental Disturbance %
406	28	S	3	4.2	1.6	6
407	10	S	4	1.5	0.7	7
409	4	H	5	0.6	0.2	5
412	5	H	5*	0.8	0.3	6
414	4	S	0*	0.6	0.1	3
415	5	S	3	0.8	0.6	12
416	34	S	4	5.1	2.4	7
417	5	S	3	0.8	0.3	6
418	6	H	6	0.9	0.4	7
419	9	H	5	1.4	0.5	6
420	9	S	5	1.4	0.7	8
421	15	S	3	2.3	0.9	6
422	7	S	5	1.1	0.6	9
423	16	S	6	2.4	1.4	9
424	17	S	6	2.6	1.5	9
425	12	S	6	1.8	1.1	9
426	16	S	5	2.4	1.3	8
427	11	H	5	1.7	0.6	5
428	1	H	5	0.2	0.06	6
429	8	H	6	1.2	0.5	6
430	4	H	6	0.6	0.3	8
432	6	H	5*	0.9	0.3	5
433	4	H	5	0.9	0.2	5
434	9	S	2*	1.4	0.5	6
435	14	S	3	2.1	0.8	6
437	5	T	4	0.8	0.3	6
438	13	S	0*	2.0	0.4	3
440**	98	underburn	5	14.7	7.0	7
700	33	T	2*	5.0	1.6	5
701	9	T	2*	1.4	0.4	4
702	6	T	2*	0.9	0.3	5
704	7	T	6*	1.1	0.6	9
705	4	S	6*	0.6	0.4	10
706	14	T	6*	2.1	1.3	9
707	19	H	6*	2.9	1.2	6
708	19	CGB	6*	2.9	1.7	9
709	4	T	12*	0.6	0.6	15
710	2	H	12*	0.3	0.25	13

*estimated from field data

**Unit 440 was inadvertently omitted from Table 12 in the Soil Report (May 2, 2007)

Table 7. Continued

Unit No.	Acres	Logging system	Existing Detrimental Disturbance %	Detrimental Disturbance Threshold @15% acres	Cumulative Detrimental Disturbance acres	Cumulative Detrimental Disturbance %
711	22	T	4*	3.3	1.5	7
712	1	S	4*	0.2	0.07	7
713	10	S	2*	1.5	0.5	5
714	92	CGB	2*	13.8	4.5	5
716	9	CGB	1*	1.4	0.4	4
717	4	T	5*	0.6	0.3	8
718	11	S	5*	1.7	0.9	8
719	10	H	5*	1.5	0.6	6
720	24	S	3*	3.6	1.4	6
721	8	T	3*	1.2	0.5	6
722	6	T	3*	0.9	0.4	7
723	36	T	5*	5.4	2.9	8
724	9	S	5*	1.4	0.7	8
725	31	CGB	7*	4.7	3.3	11
726	8	S	7*	1.2	0.8	10
727	5	H	7*	0.8	0.4	8
728	18	T	7*	2.7	2.3	7
729	9	H	7*	1.4	0.7	8
730	15	S	7*	2.3	1.5	10
731	13	S	2*	2.0	0.7	5
732	12	CGB	2*	1.8	0.6	5
733	30	CGB	2*	4.5	1.5	5
734	1	H	6*	0.2	0.03	3
735	3	S	2*	0.5	0.2	7
736	14	H	8*	2.1	1.2	9
737	6	H	8*	0.9	0.5	8
738	39	CGB	2*	5.9	1.9	5
739	27	H	2*	4.1	0.7	3
740	4	T	3*	0.6	0.2	5
741	6	S	3*	0.9	0.4	7
742	4	S	9*	0.6	0.5	13
743	4	T	9*	0.6	0.5	13
744	3	S	6*	0.5	0.3	10
745	8	T	6*	1.2	0.7	9
746	11	T	9*	1.7	1.3	12
747	4	H	9*	0.6	0.4	10
748	3	MH	0*	0.5	0.1	3

*estimated from field data

Table 7. Continued

Unit No.	Acres	Logging system	Existing Detrimental Disturbance %	Detrimental Disturbance Threshold @15% acres	Cumulative Detrimental Disturbance acres	Cumulative Detrimental Disturbance %
749	6	T	0*	0.9	0.2	3
750	2	CGB	1*	0.3	0.08	4
751	10	S	1*	1.5	0.4	4
752	18	T	1*	2.7	0.7	4
753	5	CGB	1*	0.8	0.2	4
754	2	T	1*	0.3	0.08	4
755	15	S	1*	2.3	0.7	5
756	21	T	13*	3.2	3.3	16
757	8	H	13*	1.2	1.1	14
759	21	T	3*	3.2	1.2	6
760	24	T	3*	3.6	1.4	6
761	2	T	0*	0.3	0.06	3
762	9	S	0*	1.4	0.3	3
763	14	S	2*	2.1	0.7	5
764	12	S	2*	1.8	0.6	5
765	8	TE	2*	1.2	0.3	4

*estimated from field data

Table 8. Significance factors for the Preferred Alternative on the Soil Resource

INTENSITY FACTORS	HOW APPLICABLE TO THE SOIL RESOURCE
Beneficial and adverse impacts	Provides long-term protection for soil productivity for the project area.
The degree to which the proposed action affects public health	None
Unique characteristics of the geomorphic area	Diverse landforms and soils
The degree to which the effects on the human environment are likely to be highly controversial	None
The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks	None
The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration	None
Whether the action is related to other actions with individually insignificant but cumulatively significant impacts	None
The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places, or may cause loss or destruction of significant scientific, cultural, or historical resources	None
The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973	None
Whether the action threatens a violation of Federal, State, or local law or other requirements imposed for the protection of the environment	No

Table 9. Post-wildfire soil erosion rates by soil burn severities

SMU	Burn Severity	K-factor	Slope	Rainfall	Cover	Tons/acre
125	1	0.17	2.5	30	0.009	0.11475
125	1	0.17	7.32	30	0.009	0.335988
125	2	0.17	2.5	30	0.035	0.44625
125	2	0.17	7.32	30	0.035	1.30662
125	3	0.17	2.5	30	0.096	1.224
125	3	0.17	7.32	30	0.096	3.583872
125	4	0.17	2.5	30	0.244	3.111
125	4	0.17	7.32	30	0.244	9.109008
128	1	0.28	2.5	30	0.009	0.189
128	1	0.28	7.32	30	0.009	0.553392
128	2	0.28	2.5	30	0.035	0.735
128	2	0.28	7.32	30	0.035	2.15208
128	3	0.28	2.5	30	0.096	2.016
128	3	0.28	7.32	30	0.096	5.902848
128	4	0.28	2.5	30	0.244	5.124
128	4	0.28	7.32	30	0.244	15.00307
130	1	0.28	2.5	30	0.009	0.189
130	1	0.28	7.32	30	0.009	0.553392
130	2	0.28	2.5	30	0.035	0.735
130	2	0.28	7.32	30	0.035	2.15208
130	3	0.28	2.5	30	0.096	2.016
130	3	0.28	7.32	30	0.096	5.902848
130	4	0.28	2.5	30	0.244	5.124
130	4	0.28	7.32	30	0.244	15.00307
141	1	0.17	2.5	30	0.009	0.11475
141	1	0.17	7.32	30	0.009	0.335988
141	2	0.17	2.5	30	0.035	0.44625
141	2	0.17	7.32	30	0.035	1.30662
141	3	0.17	2.5	30	0.096	1.224
141	3	0.17	7.32	30	0.096	3.583872
141	4	0.17	2.5	30	0.244	3.111
141	4	0.17	7.32	30	0.244	9.109008
142	1	0.19	2.5	30	0.009	0.12825
142	1	0.19	7.32	30	0.009	0.375516
142	2	0.19	2.5	30	0.035	0.49875
142	2	0.19	7.32	30	0.035	1.46034
142	3	0.19	2.5	30	0.096	1.368
142	3	0.19	7.32	30	0.096	4.005504
142	4	0.19	2.5	30	0.244	3.477
142	4	0.19	7.32	30	0.244	10.18066

Table 9. Continued.

SMU	Burn Severity	K-factor	Slope	Rainfall	Cover	Tons/acre
170	1	0.17	2.5	30	0.009	0.11475
170	1	0.17	7.32	30	0.009	0.335988
170	2	0.17	2.5	30	0.035	0.44625
170	2	0.17	7.32	30	0.035	1.30662
170	3	0.17	2.5	30	0.096	1.224
170	3	0.17	7.32	30	0.096	3.583872
170	4	0.17	2.5	30	0.244	3.111
170	4	0.17	7.32	30	0.244	9.109008

Burn severity: 1= unburned; 2= low; 3= moderate; 4= high
Slope factor: 2.5 = <35% slopes; 7.32 = >35% slopes
SMU: 125, 128, 130, 142, 170 have granitic parent material
SMU: 141 has metamorphic parent material

Table 10. USLE Model Results as Risk ratios

7^{th}-field Watershed	No Action	No Action + Wildfire	Alt 2	Alt. 4	Alt. 5	Preferred Alt.
Hdwters Cottonwood	0.41	0.43 (4.9%)	0.42 (2.4%)	0.42 (2.4%)	0.42 (2.4%)	0.42 (2.4%)
Beaver-Grouse	0.94	**2.63 (180%)**	0.98 (4.3%)	0.99 (5.3%)	0.99 (5.3%)	**1.03 (9.6%)**
Deer-Beaver	0.94	**1.07 (13.8%)**	0.96 (2.1%)	0.96 (2.1%)	0.95 (1.1%)	**1.02 (8.5%)**
Hungry	**1.34**	**1.34 (0)**	**1.34 (0)**	**1.35 (0.7%)**	**1.35 (0.7%)**	**1.34 (0)**
Long John	0.88	**2.03 (131%)**	0.97 (10.2%)	0.97 (10.2%)	0.96 (9.1%)	0.98 (11.4%)
Upper Cow	0.66	0.70 (6.1%)	0.67 (1.5%)	0.67 (1.5%)	0.66 (0)	0.66 (0)
5^{th}-field Watershed Beaver Creek	**1.17**	**1.46 (24.8%)**	**1.18 (0.9%)**	**1.18 (0.9%)**	**1.18 (0.9%)**	**1.19 (1.7%)**

Values in parenthesis represent the % increase over background.

Table 11. Soil burn severity by acres by 7th field watersheds

7th Field Watershed	High Burn Severity Acres	Moderate Burn Severity acres	Low Burn Severity acres
Headwaters Cottonwood Ck.	0	0	212
Beaver/Grouse Creek	581(25%)	0	1,758(75%)
Deer-Beaver Creek	0	0	430
Long John Creek	205(7%)	599(21%)	2,048(73%)
Upper Cow Creek	0	71	179
Total Acres	786(13%)	670(11%)	4,627(73%)